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An Assessment of the Accuracy of the UKF Max/Min Thermometer used for 'On-Site' T-Sum Measurements

By C P Roe

Summary

UKF's maximum/minimum thermometers were checked for accuracy against 'standard' Meteorological Office (MO) thermometers in four separate trials during January, February and March 1984. In each case the UKF thermometer consistently underestimated the actual daily mean temperature and hence the accumulated T-sum. The difference was largest when the MO thermometers were exposed in a Stevenson Screen (i.e. normal Met. Office practice) and over a 75 day period the UKF daily mean temperature was about 1°C below the MO value on average. This produced a UKF T-sum some 20% below the MO value, over the same period. This is one reason why the T-sums published in Farmers Weekly are less than those obtained from the MO T-sums service.

Inter-comparisons between three of the UKF thermometers also showed that they were inconsistent in their readings.

Introduction

In January 1983 the Meteorological Office and the magazine Farmers Weekly (using data suppled by UKF) began their respective T-sum services. Over the two seasons since their inception it has become clear that the FW scheme consistently estimates lower T-sums than those of the Met. Office. Hume (1983) showed this was partly due to the fact that the Met. Office figures were corrected to sea level whereas the FW figures applied to some unspecified height above sea level. However, the difference is too large to be explained by this height disparity alone and so other reasons were sought.

The most striking difference between the two services lies in the quantity and quality of the input data. The Met. Office uses daily observations of temperature from around 150 stations in the UK taken by trained observers using top quality instruments. In contrast FW use routine observations taken by between 700 and 800 untrained observers (often farmers) using maximum/minimum thermometers supplied by UKF. The purpose of this note is to discuss whether UKF's thermometers accurately measure max and min temperatures and to estimate the influence of any errors on 'T-sums'.

2. Equipment

2.1 UKF Max/Min Thermometers

A green plastic case houses a U-bend 'six's' thermometer (see Fig. 1). Markers in the left and right hand columns indicate the minimum and maximum temperature respectively at their lower ends; the indices are retained in position by the magnetised temperature scale and re-setting is by means of a push button on the front of the instrument which reduces the retaining influence of the magnetised scale. Both max/min scales are calibrated in whole degrees over the range -30 to 50°C (40 to 120°F); it is very difficult to read the temperature to closer than ½°C. S Brannan and Sons Ltd., Cleator Moor, Cumbria CA25 5QE manufacture the thermometer which, at the time of writing, costs just under £5. They claim accuracy to within ± 1°C for the max and min.

2.2 Met. Office Thermometers

Separate alcohol-in-glass and mercury-in-glass thermometers were used to measure minimum and maximum temperatures respectively. The thermometers are calibrated in 0.5°C increments and can easily be read to tenths of a degree. The instruments are manufactured by Casella, London Ltd at a current cost of approx. £25 each, and accuracy of ± 0.1°C is claimed.

3. Method

UKF thermometers were compared against Met. Office thermometers in four separate trials. Each trial began in January or February 1984 and continued until March 31 1984 in most cases. In each case the UKF thermometer was mounted on a post adjacent to the MO thermometers and sited according to UKF's instructions i.e. "the thermometer should be sited facing north on a post about chest height and avoiding direct sunlight or direct sources of heat e.g. buildings". Readings were made daily at two trials and on weekdays only at the two remaining sites; observations were made as near to 0900 GMT as possible. Site details for each of the four experiments are given below.

3.1 SAWS (Synoptic Automatic Weather Station) site at Trawsgoed, Aberystwyth, Dyfed. NGR 2674 2736 Height 70m asl

The MO thermometers were mounted in a Stevenson Screen and readings taken daily at 0900 GMT over the period 17 January to 31 March by the usual Met. observer, Mr John Lewis (and deputies). The site lies in a frost hollow at the base of a W-NWly facing hill slope of the Ystwyth Valley. It is particularly exposed to winds funnelled by the valley from a SE thro' W to N'ly direction. The results from this trial are the most important since they compare directly observations which form part of the Met. Office and FW T-sum schemes. In the other 3 trials the MO thermometers were not exposed in a screen and so do not afford a true comparison.

3.2 The Mansion, Trawsgoed. NGR 2671 2732 Height 55m asl.

Two UKF* thermometers mounted on separate posts were compared against MO max and min thermometers placed in 'cocoa-tins' alongside on a separate post. Readings were taken on weekdays only by myself (or Dr J Starr, RAMO) beginning on January 25 for one UKF thermometer and on February 22 for the other. The Mansion site is only 5 mins walk from the SAWS site in 3.1 and lies at the very bottom of the Ystwyth Valley and so experiences slightly colder night time temperatures. Also nearby buildings and trees afford good shelter to winds from all sectors except from a NE thro'E to SE'ly direction.

3.3 Port Dinorwic, Gwynedd. NGR 2503 3607 Height 100m asl.

A combined max/min MO thermometer was set up on a post (not in a 'cocoa-tin') adjacent to a UKF thermometer in a small garden. Readings were kindly taken by Mr Dewi Williams, DAO, Caernarfon each morning at 0815 GMT but unfortunately, the MO thermometer was only read to the nearest 0.5°C. Data were recorded over the period 1 February to 12 March 1984. The site is exposed to winds from a N-NE'ly direction and is not over-sheltered to winds from most other directions.

* One of the thermometers was supplied direct by Brannan Thermometers Ltd. and does not bear the UKF insignia. However, it is identical in every respect to the other UKF thermometers.

4. Results and Discussion

Data from each trial were considered separately because of the incompatability of the periods and method of exposing the MO thermometers at each trial. Analysis was by means of a simple mean, standard deviation and extreme value approach. Daily temperature differences (MO-UKF temperature) were calculated for max, min and mean temperatures and a statistical analysis was performed on each; see Tables 1a to 1d. The results raise the following points :-

4.1 The temperature difference between the MO and UKF thermometers depends very much on exposure. When the MO thermometers were screen mounted (at SAWS site), a mean temperature difference of 1°C was found, the MO thermometer reading higher. If, on the other hand, the MO thermometers were mounted in a 'cocoa-tin' or directly onto a post, the difference was reduced to around 0.5°C (range 0.3 to 0.7°C). However, in order to make a direct comparison of the data sources used in the Met. Office and Farmers Weekly T-sum services then it is appropriate to take the results from the SAWS site for the comprison.

4.2 Daily plots of mean temperature, MO against UKF, are shown in Figs. 2, 3 and 4 for the SAWS, Mansion and Port Dinorwic trials respectively. Clearly the MO mean is most often greater than the UKF mean.

Note also the sometimes exceptional differences between the mean, especially at the SAWS site. On one occasion MO exceeded UKF mean by 6°C (Fig. 2) as a result of the UKF max and min being 5°C and 6.8°C toolow respectively! Such an occurrence may be explained by radiative effects on the plastic casing. 'Fluttering' of the thermometer (thereby dislodging the (vertical) indices) is a likely explanation when such anamolous readings occur in strong wind conditions.

4.3 A glance at Tables 1b and 1c and Fig. 3 shows that the Brannan thermometer is subject to smaller discrepancies than the UKF thermometer. Both thermometers were sited within inches of each other at the Mansion and at roughly the same height so the reason for the difference is either because of the different trial periods or because the thermometers are inconsistent in their accuracy.

The SAWS and Mansion UKF/Brannan thermometers were set up side by side on posts at the Mansion site for a short period to see how consistent they were. Their separation and siting was such that any differences revealed could be attributed to the thermometers themselves rather than to localised variations in environmental temperature. The findings are tabulated below :-

Period: 10-23 April 1984

KEY 1 : UKF Max/min from Mansion trial
2 : Brannan max/min from Mansion trial
3 : UKF max/min from SAWS trial

Average difference	max	min
1 - 2	0.7	- 1.1
1 - 3	0.5	- 0.3

Thermometers 1 and 3 agree fairly closely but the Brannan consistently read higher minima and lower maxima than the other two. Spot readings of air temperature, taken by reading the max/min columns instantaneously showed the two UKF thermometers to be consistent; the Brannan however read 1°C higher in the minimum column than the maximum column.

4.4 The calibration of the scales of the UKF thermometers meant it was difficult to read the instrument to better than $\frac{1}{2}^{o}$C, and this fact undoubtedly contributed to the differences shown in Table 1. In fact in UKF's literature accompanying each thermometer, examples show T-sums being calculated using daily max and min read in whole degrees; evidently this will contribute further to differences observed between the Met. Office and Farmers Weekly T-sums.

4.5 T-sums calculated from observed MO and UKF temperatures at the SAWS site (17 January to 31 March) are plotted in Fig. 5. Over the 75 day period (3 days were missed when the UKF thermometer was not read), in which there were several cold and mild spells, the MO T-sum had reached 327 compared to a UKF T-sum of 259 - a difference of 21%. In terms of nitrogen application, T-200 would have been reached 15 days later in the UKF scheme.

5. Conclusions

The UKF thermometer is both inaccurate and inconsistent for recording accurate 'on-site' T-sums. More satisfactory T-sum estimates can be obtained from the Met. Office T-sum service which Sparks (1983) has shown will produce satisfactory estimates for most sites except those at high altitude (> 350m) or with steep north or south facing slopes. At these sites 'on-site' temperature recordings using accurate thermometers in a good well exposed screen will produce better estimates.

However, one is aware that UKF have the commercial interest, and direct farmer involvement in 'on-farm' T-sum recordings has clearly created awareness of the need for timely nitrogen application.

As a result of the findings of this report, UKF plan to reduce the number of farmers participating in the FW scheme and improve both the quality and exposure of their thermometers.

6. References

Hume, C J (1983) A comparison of the routine T-sum services of the Meteorological Office and of Farmers Weekly in 1983. Agricultural Memorandum No 1008*.

Sparks, W R (1983) A comparison of on-site observations of T-sums with values interpolated from synoptic weather data. Agricultural Memorandum No 993*.

7. Acknowledgements

The help of Mr John Lewis (and deputies) of the SAWS site at Trawsgoed and Mr Dewi Williams, DAO, Caernarfon in reading the thermometers is very much appreciated. Thanks also to UKF and Brannan Thermometers Ltd who supplied the necessary equipment. The advice of Dr John Starr of the Regional Agro-Met. Department at Trawsgoed is gratefully acknowledged.

Any comments on suggestions on this paper should be sent to the author.

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* Copies available from the National Meteorological Library, Meteorological Office, London Road, Bracknell, Berks RG12 2SZ

TABLE 1 : ANALYSIS OF DAILY MEAN, MAXIMUM AND MINIMUM TEMPERATURE DIFFERENCES BETWEEN MET. OFFICE AND UKF/BRANNAN THERMOMETERS

1a SAWS SITE, JANUARY 17 - MARCH 31 1984

Daily Temperature	Number of records	Temperature Difference (MO -UKF) Mean	Standard Dev.	Extreme
Mean	72	1.1	1.69	6.2
Maximum	73	0.2	2.46	5.7
Minimum	73	2.0	1.96	7.6

1b MANSION SITE, UKF THERMOMETER, JANUARY 25 - MARCH 31 1984

Daily Temperature	Number of Records	Temperature Difference (MO -UKF) Mean	Standard Dev.	Extreme
Mean	35	0.7	0.67	2.2
Maximum	50	- 0.2	1.08	4.0
Minimum	50	1.7	0.74	3.4

1c MANSION SITE, BRANNAN THERMOMETER, FEBRUARY 22 - MARCH 31 1984

Daily Temperature	Number of Records	Temperature Difference (MO -Brannan) Mean	Standard Dev	Extreme
Mean	21	0.3	0.33	0.9
Maximum	28	0.4	1.20	5.7
Minimum	28	0.4	0.36	1.2

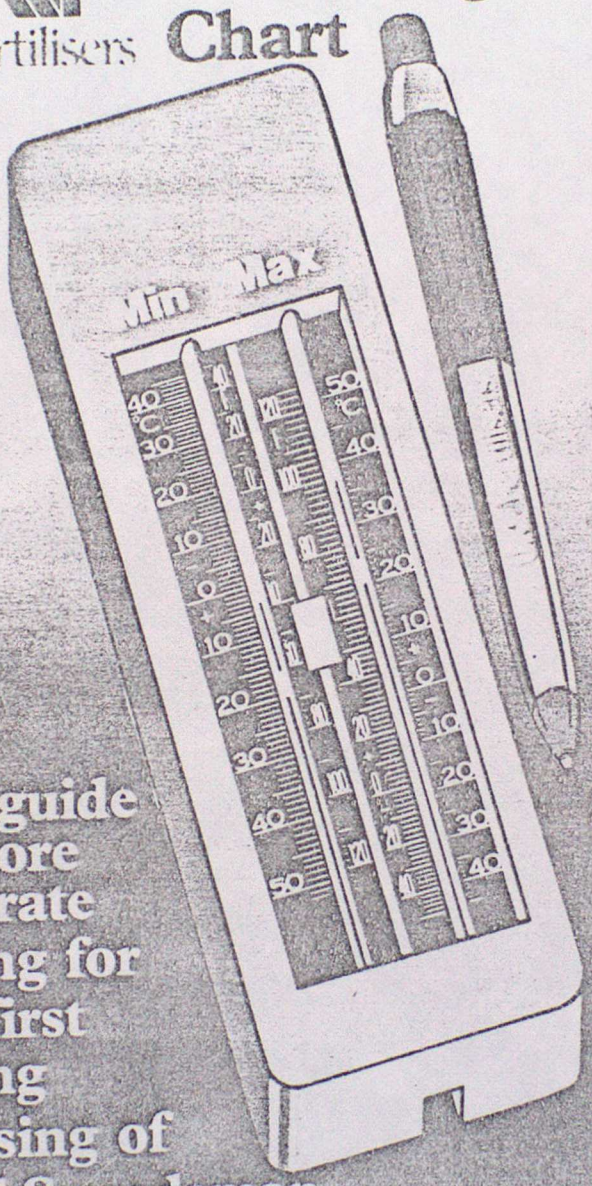
1d PORT DINORWIC, FEBRUARY 1 - MARCH 12 1984

Daily Temperature	Number of Records	Temperature Difference (MO -UKF) Mean	Standard Dev.	Extreme
Mean	41	0.6	0.88	2.5
Maximum	41	0.6	0.90	3.0
Minimum	41	0.7	1.47	4.5

FIG 1

UKF Fertilisers

UKF T°-Sum Recording Chart



The guide to more accurate timing for the first spring dressing of UKF Swardsman fertilisers

FIG 2

COMPARISON OF DAILY MEAN TEMPERATURES MEASURED IN A STEVENSON SCREEN USING STANDARD MET. OFFICE THERMOMETERS WITH THOSE MEASURED BY A UKF MAX/MIN THERMOMETER MOUNTED ON A POLE.

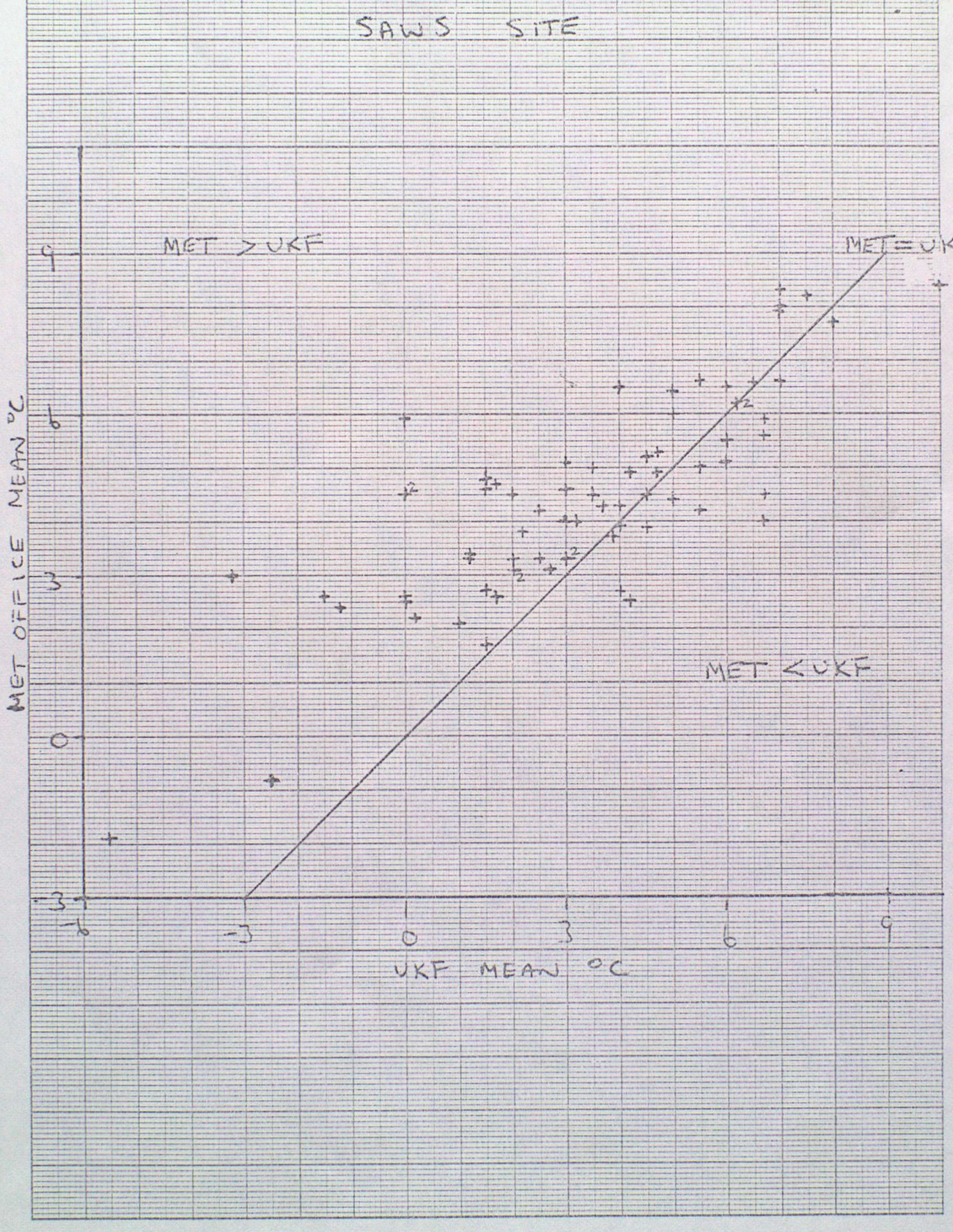


FIG 3

COMPARISON OF DAILY MEAN TEMPERATURES MEASURED IN A 'COCOA-TIN' USING STANDARD MET. OFFICE THERMOMETERS WITH THOSE MEASURED BY A UKF/BRANNAN MAX/MIN THERMOMETER MOUNTED ON A POLE.

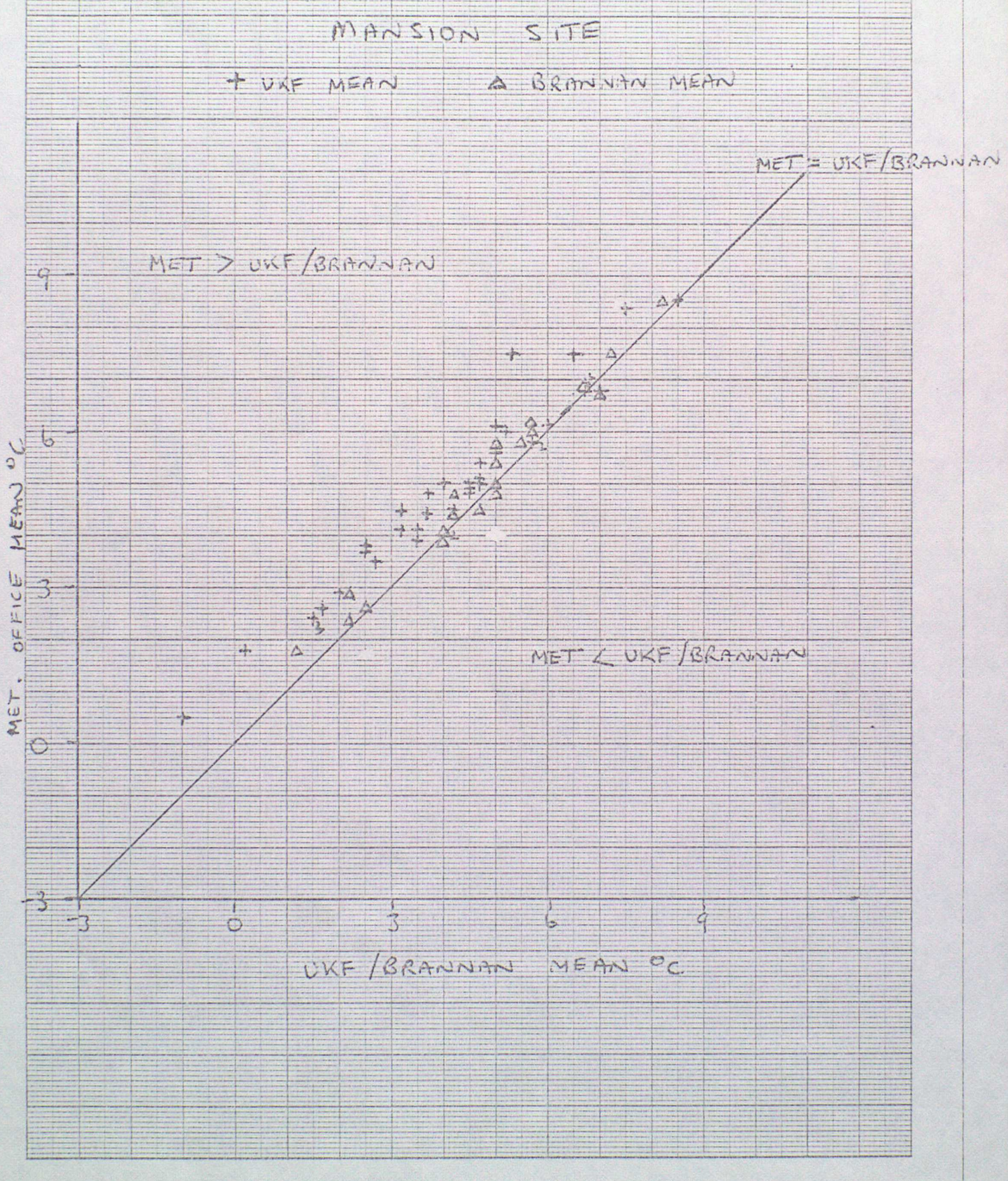


FIG 4

COMPARISON OF DAILY MEAN TEMPERATURES MEASURED BY A MET MAX/MIN THERMOMETER MOUNTED ON A POST WITH THOSE MEASURED BY A UKF MAX/MIN THERMOMETER MOUNTED ON A POST.

PORT DINORWIC SITE.

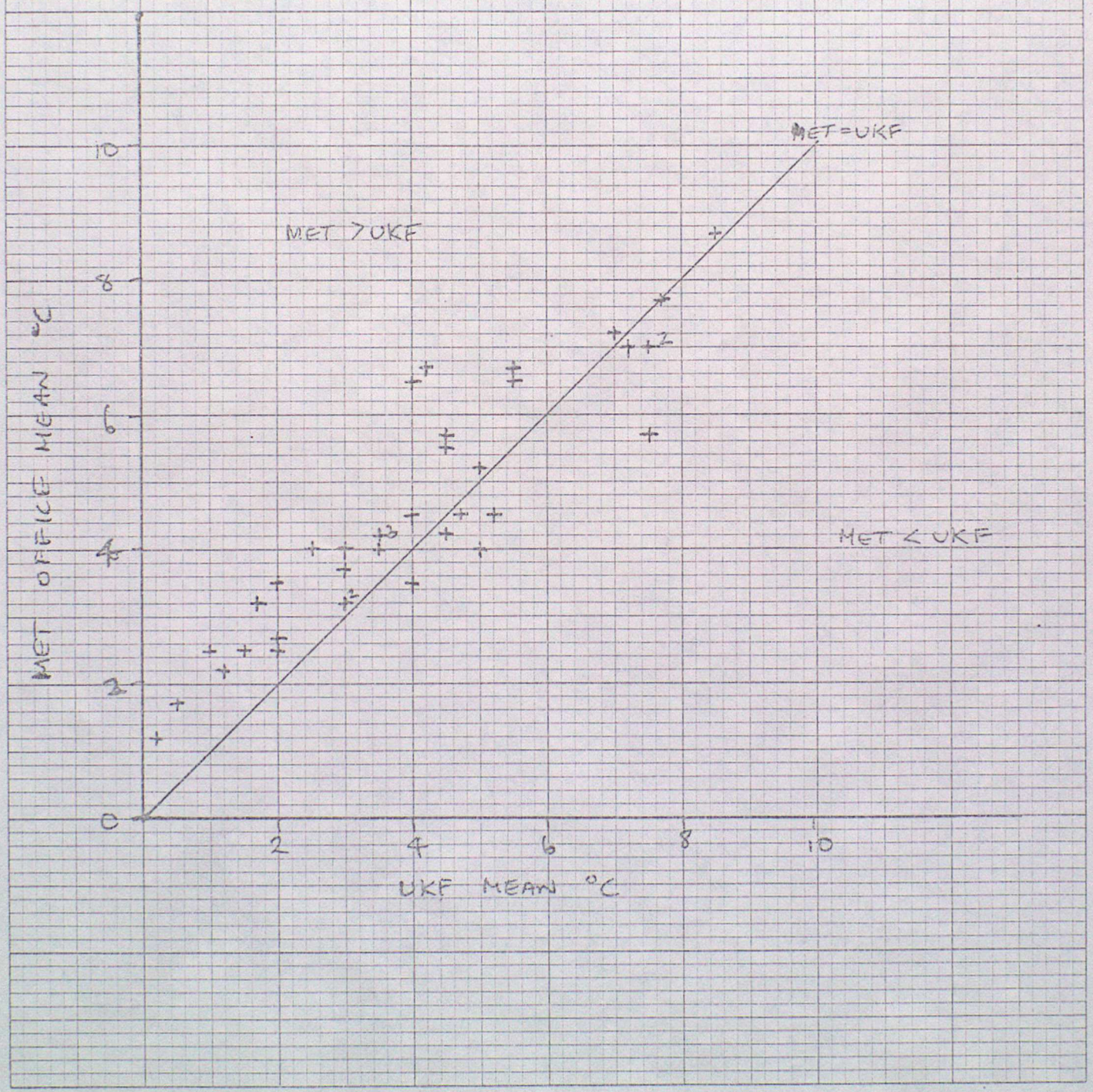
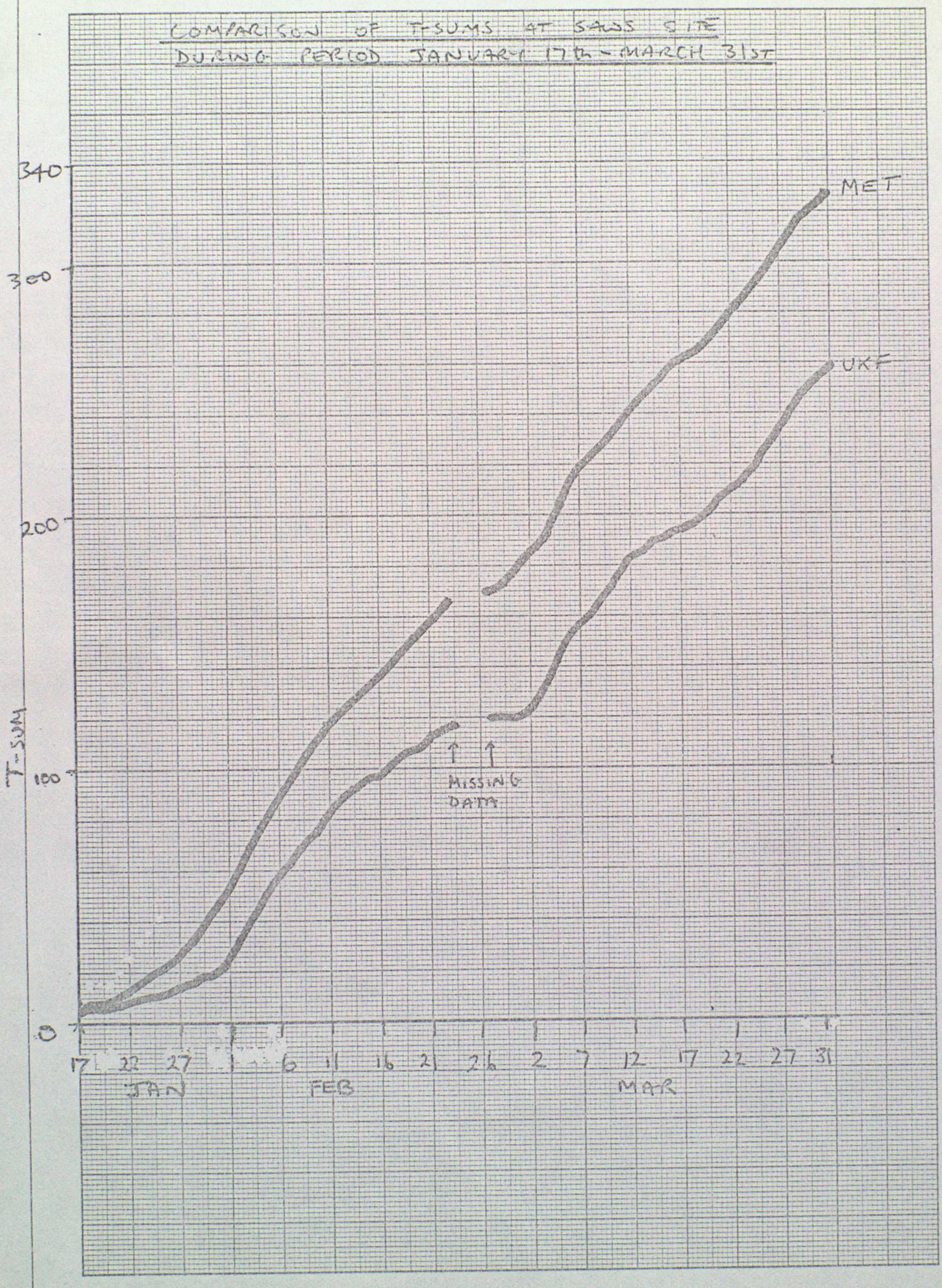


FIG 5


COMPARISON OF T-SUMS AT SAWS SITE
DURING PERIOD JANUARY 17th - MARCH 31ST
340
300
200
100
0
T-SUM
MET
UKF
MISSING DATA
17
22
27
1
6
11
16
21
26
2
7
12
17
22
27
31
JAN
FEB
MAR